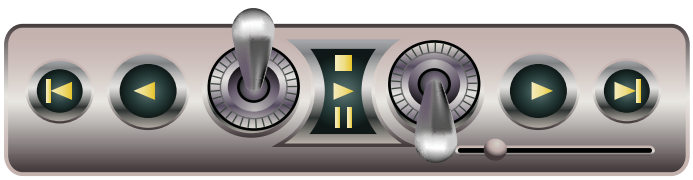
Flight Surgeon Refresher Course

Section 3: Aeromedical Training

Vibration

(FSRC306)



VIBRATION

Introduction

Air crewmembers operate in an environment that exposes them to hazardous vibration levels on a daily basis. Vibrations effect aircrew member's coordination, vision and can degrade performance in other flight-related activities.

Proper management of the effects of vibrations can enhance cockpit performance, promote a safe flying environment and ensure successful execution of the mission. We cannot eliminate vibration during flight, but we can minimize its effects by practicing good prevention techniques and using a little common sense.

Objectives:

a. Define vibration

b. Define resonant frequency

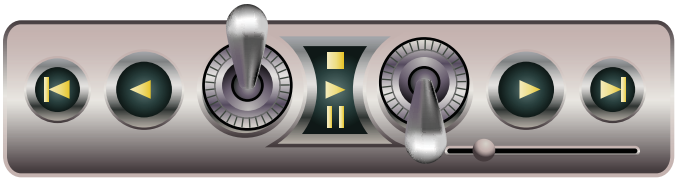
c. Define dampening

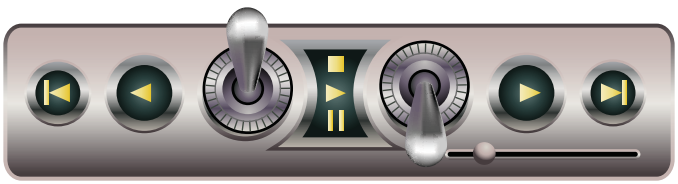
d. Identify sources of vibration

e. Describe the short-term effects of vibration

f. Describe the long-term effects of vibration

g. Describe preventive measures to reduce the danger posed by vibration





What is Vibration?

In simple terms, vibration is nothing more than shaking.

More exactly, vibration is the motion of an object, relative to a reference position (usually the object at rest), involving a series of oscillations that cause the object to displace and accelerate.

How is Vibration Measured?

- Frequency: the number of oscillations of any object measured in cycles per second (cps). The standard unit of frequency is the hertz (Hz): 1 cps equals 1 Hz.
- Amplitude: the maximum displacement about a position at rest.
- Duration: the amount of time exposed to vibration.

How does vibration affect aircrew members?

Vibration can be harmful because of the stress of shaking on tissues. Contact with a vibrating aircraft transfers vibration energy to a person's body through the aircraft seats, the flight controls or the floor. Vibrations of different frequencies can affect the crewmember's whole body or only a particular organ.

What is resonant frequency?

Each organ in the body has a natural frequency at which it vibrates. When external vibrations are transferred to the body at or near the natural frequency of an organ, the vibrations are amplified in that organ and increase the stress on the organ.

Why doesn't vibration seriously injure aviators every time they fly?

Because the connective tissue and muscles in the body dampen vibrations.

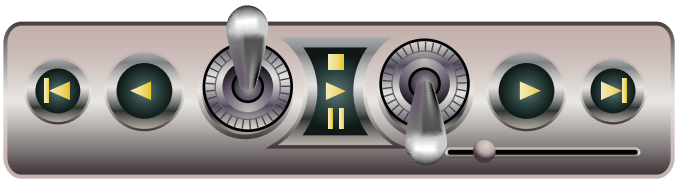
Dampening is the loss of mechanical energy in a vibrating system.

The connective tissues that bind the major organs together (and muscle tissue as well) react to vibrations like shock absorbers, reducing and slowing the vibrations to less harmful intensities.

Aircraft Vibration Sources

Vibrations are produced within the aircraft and the environment in which it operates.

	Rotary Wing Aircraft:	Fixed Wing Aircraft
Aircraft Sources	Main rotor 4-11 Hz Engine 110 Hz Tail rotor 30-60 Hz	Airframe during low altitude high-speed flight 1-10Hz Propellers 20+ Hz
Outside Sources	Weather (turbulence): crewmembers may over-control during turbulence. Increased air speed Internal and external loading	Weather (turbulence): crewmembers may over-control during turbulence. Increased air speed Internal and external loading Nap of the earth (NOE) flying



Effects of Vibration

- **Reduced muscle control.** Vibration causes the body's muscle groups to make reflex contractions. When the human body is in motion, pressure receptors located in tendons and muscles constantly measure angular position of the muscle in order to maintain posture and balance. These receptors respond to vibration, causing muscle contractions. This reduces muscular control.
- **Reduced coordination**. Vibration degrades aircrew members' ability to perform simple tasks during flight. Manual coordination and control "touch" is degraded at 4-8 Hz. A pilot can induce oscillations when he or she over-controls during turbulence and/or transition from a hover to flight.
- **Degraded vision.** Vision could be degraded due to vibration in the aircraft— shaking instruments may be difficult to read. Furthermore, helmet mounted or night vision devices may vibrate at 4-12 Hz, adding to visual disturbances.
- **Distorted speech.** Speech can be distorted during oscillations of 4-12 Hz. Above 12 Hz speech becomes increasingly difficult to interpret.

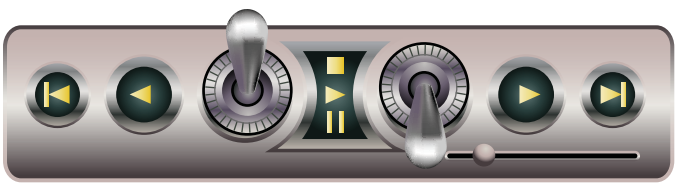
Short-Term Effects of Vibration:

- **Hyperventilation** is caused when the diaphragm is vibrated at its resonant frequency of 4-8 Hz. Hyperventilation is due to an "artificial respiration" caused by involuntary, rapid vibration of the diaphragm.
- **Increased pulse rate and blood pressure.** The body interprets vibrations during flying as exercise. Therefore, the muscular effort of bracing against vibration increases pulse rate and blood pressure.
- **Nausea**. Vibration with a frequency of less than 1 Hz (like the slow rolling of a ship) can produce nausea in susceptible people to motion sickness.
- **Fatigue.** The effect of vibration may cause aircrew to become increasingly fatigued during and after flight.
- **Balance.** Vibration affects the organs of balance in the middle ear: the semicircular canals and the otolith organs. The semicircular canals respond to the changes in angular and linear motions (pitch, roll or yaw). The otolith organs are stimulated by gravity and linear motions (vibrations and oscillations). Vibrations are sensed by these organs and causes disorientation.
- **Pain** is usually due to vibration exacerbating preexisting injuries, such as stress fractures or other traumas. Vibration aggravates those conditions.

Long-Term Effects of Vibration:

Exposure to vibration over a period of time may cause injury to aviators:

- **Raynaud's Disease** (white finger) occurs in the hands after prolonged exposure to vibration from power tools, jackhammers or other equipment that vibrates at high frequencies. It is caused by chronic trauma to the arterioles and nerve endings in the extremities. Vibration causes micro trauma, which reduces blood flow to the effected portion of the extremity.
- **Backache/back pain** in aircrew members may result at an earlier age than normal. Certain rotary wing aircraft vibrate at the resonant frequency for the intervertebral disk. The lumbar spine, in particular, is subjected to higher pressures during aircraft operation because it bears the increased weight of the torso during resonant oscillations. Bone, like other organs, requires good blood flow. When the spine is subjected to high levels of vibration, blood flow is reduced. The reduction in blood flow results in premature degeneration of bone structures within the spine.
- **Kidney damage.** Signs of overexposure to vibration include hematuria, (blood in the urine) and albuminuria (albumen in the urine).
- **Lung damage** may result after prolonged exposure to vibration at resonant frequencies.



Reducing the Effects of Vibration

Vibration cannot be eliminated, but its effects on human performance and physiological functions can be lessened:

Pre-flight

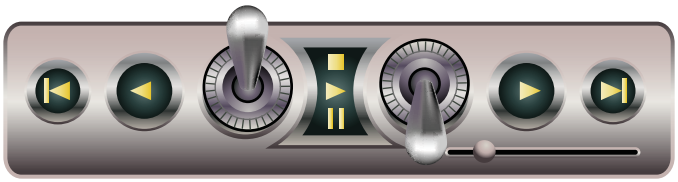
- Proper aircraft maintenance, such as blade tracking, can reduce vibration.
- Stretcher Loading. When loading patients on MEDEVAC aircraft, remember that patients on the floor will experience more vibration than patients in the upper racks.
- Maintaining excellent physical condition. Fat multiplies vibration, while muscle dampens vibration. Strong muscles dampen oscillations encountered in flight. An overweight aircrew member is more susceptible to decrements in performance from the physiological effects of vibration. Good physical condition also lessens the effects of fatigue, helping you to function during extended combat operations with minimum rest.
- Keep hydrated. Drink plenty of fluids, even if you do not feel thirsty. Dehydration coupled with vibration can worsen fatigue and increase the time needed for recovery.

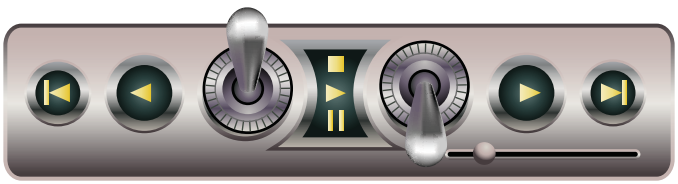
During flight

- **Maintain good posture during flight**. Sitting up straight in the seat enhances blood flow throughout the body.
- **Use of restraint systems**. Restraint systems (seat harnesses and belts) provide protection against high-magnitude vibration from extreme turbulence.

Warning: Vibration tends to be most intense during transition from hover to cruise flight and cruise to hover.

- **Body supports**, such as lumbar inserts and seat cushions, reduce discomfort and can dampen vibration. However, during a crash sequence they may increase the likelihood of injury due to their compression characteristics.
- **Limiting exposure time**. Make short flights with frequent breaks, rather than one long flight, if mission permits.
- **Let the aircraft do the work**; do not grip the controls tightly. Vibration can be transmitted through control linkages during turbulence.





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